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The Photographic Nebulæ in the Pleiades.

(Extract from a Letter from M. P. Henry to Mr. Knobel.)

Nous avons en effet obtenu sur tous nos clichés des *Pleiades*, de faibles traînées nébuleuses près de *Merope*, mais, ainsi que vous pourrez le voir sur la petite épreuve que j'ai l'honneur de vous envoyer, cette nébuleuse ne ressemble en rien à ce qu'en a donné Tempel. Elle a au contraire beaucoup d'analogie avec ce qu'a vu Mr. Common et qu'il a publié en 1882, je crois, dans les *Monthly Notices*.

Dans la petite carte ci-jointe, comme vous pourrez le voir, j'ai un peu accentué à l'aide d'un crayon blanc, les différentes taches lumineuses qui voisinent *Merope*. C'est la reproduction exacte du cliché original. Ces traces nébuleuses sont extrêmement faibles, et ne viennent que fort peu au tirage sur papier.

On peut voir aussi sur l'original une très-faible trace lumineuse partant d'*Electra* et se dirigeant vers l'Est, mais c'est une limite de visibilité, et il ne nous a pas été possible de l'obtenir en moins de 3 heures de pose ! Je l'ai indiqué à la craie sur l'épreuve, en l'exagérant, bien entendu.

J'avais l'intention avant d'envoyer à la Roy. Ast. Soc. une carte complète des *Pleiades* avec la nébuleuse de *Merope*, d'essayer d'obtenir cette dernière un peu plus intense s'il avait été possible, mais malheureusement le temps n'a pas été suffisamment beau, et nous devons nous en tenir, jusqu'à l'année prochaine du moins, à ce que nous avons déjà.

Note on some recently published Spectroscopic Observations.
By E. W. Maunder.

There have been published recently three series of spectroscopic observations to which I should like to draw the special attention of the Society, as each in its own department is of considerable novelty and importance, and it seems to me that it is, on that account, very desirable that they should not take their place among the accepted facts of science without a thorough and searching criticism. It may seem ungracious thus to challenge definite and positive observations; but I need scarcely say that I have not the smallest idea of calling in question the good faith of the observers. My only wish is to draw such attention to the observations referred to as may result in the publication of further details respecting them, or in inducing other observers to make such further researches in the same directions as may confirm or discredit those before us. I am aware that it is not very usual for papers read before the Society to be of a merely critical character; but if the present Note should lead to the bringing out of further and more decisive results, I do not think it will have been useless.

I. Bright Lines in Stellar Spectra. Mr. O. T. Sherman. *Science*, vol. vi., pp. 262, 336, and 386; *Amer. Jour. of Science*, vol. xxx. pp. 378 and 475; *Astronomische Nachrichten*, Nos. 2707 and 2709.

The first series of observations to which I would ask attention is the detection of bright lines in stellar spectra, by Mr. O. T. Sherman, of Yale College Observatory. The first published observation by Mr. Sherman appeared in the number of *Science* for September 18, 1885, and described the detection of certain bright lines in the spectrum of *Nova Andromedæ*. A second communication furnished the positions of these lines, and I was naturally much gratified to find that Mr. Sherman's determinations agreed with the rough estimations I myself had made, in a manner which was really remarkable when the difficulty of the observation was borne in mind. Mr. Sherman has since examined the spectra of many other stars, beginning with β *Lyræ* and γ *Cassiopeiæ*. In these two he found not only the bright lines of hydrogen usually seen, but a number of other bright lines, corresponding apparently to the principal lines of the solar chromosphere. In all seventeen bright lines were detected in the spectrum of β *Lyræ*.

So far, though Mr. Sherman's results were both interesting and striking, there was nothing on the surface to provoke scepticism. The two stars in question are known to have certain bright lines in their spectra, and it might well be that an observer might detect fresh ones, either by the aid of a special equipment, or by means of an exceptionally keen sight. But Mr. Sherman

has since examined the spectra of some fifty other stars, and his report upon them is that "in *each* case many or few bright lines have been seen." It is clear that if this statement can be substantiated, we have here an advance in stellar spectroscopy of the most important character. The question naturally arises as to what was the instrumental means at the observer's command?

The telescope employed had an aperture of 8 inches; the spectroscope was a direct-vision one, with two sets of prisms, three in each set. With one set of prisms b_3 and b_4 are barely separated; with both sets the nickel line between D_1 and D_2 is seen. The collimator is about six inches long, and "the power of the eyepiece of the observing telescope is about 130," meaning, I suppose, the power which the eyepiece would have if used on the Equatorial telescope of 8-inch aperture, and not the power it would have when taken in conjunction with the viewing telescope of the spectroscope alone.

So far there seems little ground for criticism; the instrument, if not specially powerful, would seem fairly suited to the work; but there seem some points in Mr. Sherman's further account of his method which, if I rightly interpret them, indicate, I would venture to think, a faulty procedure.

First: "previous to each night's work the instrument was adjusted upon the Sun; a solar spot, when possible, being brought sharply in focus upon the jaws of the slit." This would seem a proper and necessary adjustment, and would suffice for the centre of the spectrum; but for the extreme rays, especially the blue and violet, the spectroscope would not be in the proper focus of the equatorial. There is a paragraph in Mr. Sherman's paper which at least suggests that the extreme ends of the spectrum suffered from maladjustment in this way: "At the red end under a sharp focus they" (the bright lines) "stand out the full breadth of the spectrum, bearing somewhat the same relation to the background as the prominence to the solar spectrum. In the brighter portion of the spectrum they are cut down to fine star-points. At the blue end they become more distinct, but not so sharp as at the red. At times they shine with almost a metallic brilliancy; at other times they are faint, faded, and easily passed over. Certain sets appear to be prominent at times, others at other times."

It seems very difficult to believe that this can be a description of the behaviour of true stellar bright lines, while it is quite conceivable that lines due to some instrumental defect might present just such an appearance in a spectroscope adjusted, as Mr. Sherman's seems to have been, only for the centre of the spectrum, particularly as he placed his cylindrical lens, not before the slit, nor even in the viewing telescope, but between the eyepiece and his eye.

Secondly: Mr. Sherman used an unusually wide slit, "5^{mm} or more." I think most stellar spectroscopists will pronounce

this to have been fully 100 times too wide. 5^{mm} in the focus of the 8-inch object-glass would correspond to $6'$ of arc. It seems hard to see what purpose a slit of so great a width would serve, and in what essential feature it differed from no slit at all. And it is also difficult to place much confidence in measures made with so wide a slit, especially as the collimator only measured 6 inches in focal length, so that no stress can be laid upon the correspondence between the bright lines observed, and those seen in the solar chromosphere.

The most suspicious circumstance of all, however, is, I think, that so far Mr. Sherman has never failed to see bright lines in any star which he has examined; and that though "sometimes they shine with almost a metallic brilliancy," yet no previous observer has ever detected them.

My experience of bright lines in stellar spectra has been limited to γ Cassiopeia, and perhaps Nova Andromedæ. But I have had occasion to notice on more than one occasion that a stellar spectrum which is full of dark lines or bands may, when badly seen, give a very perfect illusion of bright lines; the dark lines escaping recognition as such, but producing their effect by making the parts of the spectrum most free from them shine out by contrast like a veritable chromospheric spectrum. I have also, in my measures of the displacement of lines in stellar spectra, used on some 100 stars a dispersion considerably greater than Mr. Sherman's, the very greatest, in fact, the star would bear, without bringing up the faintest trace of a bright line; so that I cannot put down my own failure to detect these lines to insufficient dispersive power.

Since I commenced to draw up this note, Prof. Vogel has criticised* Mr. Sherman's observations in the *Astronomische Nachrichten*, on grounds which closely correspond to some of those which I have here brought forward; but he mentions in addition the mistake which Secchi fell into with regard to the spectrum of Sirius; an instance which shows how readily even an experienced spectroscopist may be made the victim of an instrumental illusion.

II. Observations of the Spectrum of Nova Orionis. Dr. Ralph Copeland. *Monthly Notices*, vol. xlv. No. 3.

In venturing to criticise Dr. Copeland's paper on the spectrum of the new star near χ_1 Orionis read before this Society at the January meeting, I have not the smallest intention of calling in question the observations themselves. These are undoubtedly very accurate; the only point open to question is the interpretation to be put upon them. There is no doubt as to the general appearance of the spectrum. It resembles the spectra of Secchi's third type, of which α Orionis, α Herculis, Mira Ceti, and β Pegasi are amongst the best known examples. But the contrasts of

* *Astron. Nachr.* No. 2712.

light and darkness are unusually pronounced, so that it becomes a question whether we ought to regard the spectrum as consisting of a brilliant continuous spectrum crossed by intensely dark bands, or of a feeble continuous spectrum, with vivid bright bands superposed upon it. It is, in fact, a somewhat similar question to that raised by Dr. Henry Draper with regard to the existence in the solar spectrum of bright lines due to oxygen. Hitherto all observers seem to have preferred the former view; Dunér,* Riccò,* Thollon,† Trépied,‡ Vogel,§ and Wolf,|| however much inclined on a first view to believe in the presence of bright lines, all agreeing on more careful scrutiny to see in the spectrum of the new star but an unusually fine example of the third type, showing no very essential points of difference from that, for example, of a *Orionis*. Dr. Copeland, on the other hand, considers that "the spectrum is not so much a continuous one, interrupted by dark lines and dusky bands, as a *not very luminous spectrum upon which a series of bright bands are superposed*." Further, he identifies some of these bands, as those so well known to us as characteristic of hydro-carbon and of cometary spectra.

Of the importance of this view, if it can be substantiated, there can be no doubt. We cannot confine it to a single member of the type, but must regard *all* the stars of Secchi's third group as possessing a similar constitution. For the characters and positions of the bands are practically the same throughout all the members of the group; the only difference being in their comparative intensity. And in this respect we have every conceivable gradation from the bold and beautiful contrasts of the present star and of a *Herculis*, ρ *Persei*, *Mira Ceti*, and others, down to stars in which they can only just be detected. Further, many of the stars being variable, the intensity of the contrasts often varies from time to time in the same spectrum; so that there is no possibility of drawing a line, and saying, "These stars have bright bands on a feeble background, and the others dark bands on a bright background." The verdict passed on *Nova Orionis* must be passed on all the members of the same type.

The hypothesis is certainly a tempting one. Seeing that we possess spectra intermediate in character between a true solar and a pure banded type, we might, on the one hand, well be tempted to push Dr. Draper's views a little further, and see not only bright oxygen lines in some of the clear interspaces of the solar spectrum, but to find in others traces of hydro-carbon bands; while, on the other hand, the red stars plainly show an absorption spectrum corresponding to the hydro-carbon bands; so that the spectroscopic chain connecting together comets and the various orders of stars would be complete.

* *Astron. Nachr.* No. 2707.

† *Ibid.* vol. cii. No. 1.

|| *Comptes Rendus*, vol. ci. No. 26.

† *Comptes Rendus*, vol. cii. No. 7

§ *Astron. Nachr.* No. 2704.

But there are several difficulties in this view. First, the dark bands of spectra of the third type must be regarded as true absorption bands, and not merely as traces of a very feeble continuous spectrum appearing dark only by contrast with the vivid bright bands superposed upon it, for under favourable circumstances they have been resolved into separate fine lines; and M. Wolf believes that he has been able so to break up the bands in the spectrum of *Nova Orionis* itself. And, secondly, though at present we are unable to draw any particular inference from the fact, it can hardly be a chance coincidence that in each case the more refrangible edge, the sharp dark edge of these bands, agrees in position with some well-marked metallic line, usually with one ascribed either to iron or calcium.

Then, further, the districts of the spectrum which Dr. Copeland considers to be bright bands correspond in every case to districts which, in other spectra of the type, are simply free from absorption bands or lines. Line by line, band by band, every object Dr. Copeland has considered as a bright line or band corresponds with what in other spectra are simply regarded as clear spaces; the only difference is the somewhat greater comparative brilliancy of these spaces in *Nova Orionis*. Undoubtedly if the continuous spectrum be very bright, and the absorption bands very dark, these spaces very greatly resemble bright lines in appearance. They do so in *α Herculis*, *ρ Persei*, and several others when viewed with small dispersion, but the illusion promptly disappears when a great dispersion is employed. And in the particular instance before us, M. C. Wolf records that, though the *Nova* seemed at first to present bright lines in the blue and green, with greater dispersion he could not establish the presence of a single line.*

Further, the coincidence of Dr. Copeland's bright lines and bands with those of the hydro-carbon spectrum is by no means exact. The positions of these bands are now known with great exactness, the different investigators who have determined them agreeing very closely indeed in their results. In all, five of these bands have been detected in the spectra of comets; two of them, the red and violet, having been only rarely seen. But the other three have been frequently seen, and their exact coincidence with the bands of the hydro-carbon spectrum placed beyond dispute. The brightest band is the one in the green, wave-length, according to Thalén,† 5164 tenth-metres. Dr. Copeland identifies this with the bright space immediately following the sharp dark edge of what I have called the dark band VI.‡ But numerous and repeated observations have shown that the edge of this band coincides with the magnesium line *b*₄, the wave-length of which is 5167. The difference is indeed too small to be detected easily with such dispersion as *Nova Orionis* would bear,

* *Comptes Rendus*, vol. ci. No. 26.

† Angström and Thalén, *Recherches sur les Spectres de la Métalloïdes*.

‡ *Monthly Notices*, vol. xlv. p. 114.

but the positions both of the carbon band and of the magnesium line have been determined with far too great a degree of accuracy for the difference to be due to errors of observation. Dr. Copeland is confirmed in his view that this bright space is the green hydro-carbon band by finding a second line at λ 5137. A reference to Huggins and Miller's* drawings of the spectra of α Orionis and of Aldebaran at once explains the origin of the second line. The bright space is interrupted here by a strong dark line, ascribed by Dr. Huggins to bismuth. Dr. Copeland's measures, too, scarcely support his view. The wave-length of the hydro-carbon line is 5128; the values Dr. Copeland obtains for his bright line are 5157, 5131, and 5124.

The second band in order of brightness in the hydro-carbon spectrum begins at λ 5634. This is certainly non-existent in spectra of the third type, a broad dark band,—No. 4 in Dunér's nomenclature and my own, wave-length 5642 to 5592,†—occupies the very place. The third hydro-carbon band, that in the blue, with wave-length for its less refrangible edge 4737, is indeed not far from the bright space Dr. Copeland has observed at λ 4722, but the correspondence is certainly not very exact. But whilst the bright spaces in the spectrum of the star answer so very imperfectly to the hydro-carbon bands, the hydro-carbon bands correspond still worse to the bright spaces. As Dr. Copeland himself points out, the spaces at λ 5428 and λ 4944 correspond to no known hydro-carbon band; and there are, besides, bright lines or bands at λ 6110, λ 5841, λ 5771, λ 5592, λ 4923, and λ 4778 to find an explanation for, if the natural one, hitherto accepted, that they are simply the clear intervals between dark absorption bands, be set aside.

III. Les changements temporaires de réfrangibilité des raies du spectre de la chromosphère et des protubérances solaires. M. E. L. Trouvelot.—*Bulletin Astronomique*, January 1886.

The third series of observations of which I wish to speak are contained in a paper by M. Trouvelot in the January number of the *Bulletin Astronomique* on temporary changes of refrangibility of the lines of the spectrum of the solar chromosphere and prominences. Eight remarkable observations are very fully described, and illustrated in a series of 22 diagrams. The observation to which I would more particularly allude is the fifth, which is to the following effect:—M. Trouvelot was examining the limb of the Sun on June 26, 1874, when he found at 270° several eruptive jets, above which floated a brilliant prominence, with an apparent height of $3' 37''$. Observed with the slit opened sufficiently wide to admit the entire prominence between its jaws, the prominence resembled an immense fiery comma. But with a

* *Phil. Trans.* 1864, plate xi.

† Dunér, *Les Etoiles à Spectres de la Troisième Classe*.

narrow slit this prominence was projected whole on the spectrum on the side towards the red, and advanced upon it for its full height to a distance from the C line eight-and-a-half times the interval between the D lines.* The diagram represents the prominence as being wholly unchanged in size and appearance, whether observed through a slit opened so widely as to admit the entire prominence between its jaws, or through a slit so nearly closed that the lowest point of the prominence was well outside it. Finally, after having been attentively watched for some minutes, "it disappeared with the instantaneousness of a flash of lightning."

I mention this observation particularly because it seems to me that, if accepted, it must entirely modify our views as to the displacement of spectral lines indicating motion in the line of sight. M. Trouvelot infers from his observation that the prominence was receding with the incredible speed of 2584 km. per second. The observation involves much more than this. Had this been all, he would simply have noted a bright line, no wider than his narrow slit, situated far down the spectrum, at the point to which the extreme tip of the prominence seemed to reach. Displacements of this character, but of a much smaller amount, have often been witnessed. But what was witnessed in the present case was something very different. The "prominence," so called, extended *nearly continuously* from C to a distance of more than eight times the interval between the D lines from it, and was therefore, according to the diagram, more than twenty times as wide as the C line. If this increase in breadth and change of refrangibility was due solely to motion of the solar gas streams, it would mean, not that the part of the chromosphere under the slit was moving at the rate of 2584 km. per second, but that it was moving with every conceivable velocity from rest up to that amazing speed. The curious convolutions shown in the shape of the prominence would imply a yet greater complexity and intricacy in the movements of the gases under observation. At certain points of the limb the gases must have been moving with two or three separate ranges of velocities—say, to speak roughly, from 1,000 to 1,500 km. per second, and also from 2,000 to 2,500 km. per second, but with no velocity intermediate between these ranges. It does not seem credible that this state of things can possibly have a real existence.

M. Trouvelot records that the prominence disappeared like "a flash of lightning." He explains this disappearance as due to the prominence being carried round the limb of the Sun by its rapid motion. But, as just shown, the bulk of the prominence was not moving with the extreme velocity noted, 2,584 km. per second, but with every conceivable smaller velocity. What ought

* *Observée avec la fente plus étroite, cette protubérance se projetait en entier sur le spectre du côté de l'extrême rouge, et s'avancait sur lui de toute sa hauteur, jusqu'à une distance de la raie C égale à huit fois et demie l'intervalle Δ .*"

to have happened, therefore, was that it should have died away from its summit downwards, diminishing in brightness the while.

It should also be remembered that these velocities as referred to the Sun are not velocities of eruption in the radial line, but velocities tangential to the surface. If such movements take place in the chromosphere in the direction of the line of sight, movements similar in character should also be noticed from time to time in the direction perpendicular to that line. Hitherto, certainly, no such speeds have been witnessed. The displacements, on the contrary, which Lockyer and other observers have placed on record indicate movements which are essentially of the same order of velocity as those determined by direct observation.

M. Trouvelot mentions several other observations, only less remarkable than the one to which I have drawn attention, from which similar conclusions may be drawn. It is to be earnestly hoped that he will not hesitate to publish in the fullest detail all that he has made which bear upon the subject, and that other solar spectroscopists will do so likewise, since it seems clear that if there is nothing radically wrong in these observations, it will be no longer safe to deduce the rate of motion in the line of sight from observations of displacements in the prominence and chromospheric lines, but that we must look for their explanation to molecular motion within the gases themselves—a direction which has hitherto been scarcely regarded as admissible.

Additional Remarks on the Periodic Time of a Centauri.

By E. B. Powell.

I wish to offer some further remarks in connection with the suggestion I made in No. 1 of the *Monthly Notices* for 1884–85, to the effect that the period of a *Centauri* may be considerably longer than has generally been supposed. I agree with Mr. Downing that the test of a theoretical orbit is its standing comparison with observation; but then this test should be applied to the *whole* circuit of the comes round its primary. While a portion of the orbit is left unchecked by trustworthy observations, it is quite possible that a certain ellipse may fairly satisfy recorded measures and yet prove to some extent erroneous. In the case of a *Centauri*, the true orbit is so disguised by the manner in which it is presented to our view, that more than one perspective ellipse may be found which will agree tolerably well with recorded measures; and, if we desire to anticipate the future, when the motion round the south preceding end of the orbit will be accurately fixed by equatorial observations and the correct elements become evident, we must take note of every indication, however imperfect, which may help us to forecast the character of the path. It appears to me also that, in an instance such as the one under consideration, where the number of degrees

to be described for the completion of the circuit is small (about 17°), it is not sufficient to compare position-angles, especially as those representing observation are derived from differences of Right Ascension as well as from differences of Declination, and the errors of the former may be considerable. I think that a more satisfactory mode of testing the orbit for that portion is to find from the theoretical ellipse the differences of Declination of the components at the particular epochs and to compare these with the observed differences of Declination. Following this view, I have drawn up the following table, in which are given the differences of Declination of the several observers and those afforded by the Downing-Elkin orbit, undoubtedly the best hitherto published.

Observer.	Epoch.	Observed Diff. of Dec.	Diff. of Dec. sec. Downing-Elkin.	Obs. Diff. Dec. — Theoret. Diff. Dec.
Henderson	1833.0	14".82	14".65	+ ".17
Johnson and Taylor }	1832.15	15.98	15.07	+ .91
Rümker	1827.0	19.54	17.10	+ 2.44
Dunlop	1826.0	18.79	17.38	+ 1.41
Fallows	1823.0	25.00	17.96	+ 7.04

In connection with the table it will be well to make a few remarks.

Henderson's measure scarcely needs a comment; it is derived from 27 observations of a_1 and 29 of a_2 , taken towards the end of 1832 and the beginning of 1833.

In the case of Johnson and Taylor it seemed advisable to take the mean of their measures. The observations of the former gave diff. of Dec. = $16''.2$ for 1831.94, and those of the latter, diff. Dec. = $15''.77$ for 1832.37; the mean is entered in the table.

In Rümker's Paper in the *Phil. Transactions* for 1829 some of the measures are useless for the present purpose, owing to one component alone having been observed during the early years of Sir Thomas Brisbane's Observatory. But taking the observations for the last months of 1827, in which both components are included, we have diff. Dec. = $21''.2$ for a date which may be taken approximately as 1828.0. It is, however, to be noticed that, while a moderately large number of measures were taken of a_2 , of a_1 there were only four, and that the maximum difference of the latter was as $6''.3$. In Rümker's "Preliminary Catalogue," published at Hamburg in 1832, in which he compares his own and Lacaille's measures, the diff. Dec. of the former is put down as $19''.54$; the accompanying remarks made by him, and a consideration of the dates on which he joined and left the Brisbane Observatory, render it probable that the epoch corresponding to the above value is 1827-28. It seems not improbable that $19''.54$ was a final, and in Rümker's eyes a presumedly more accurate value than $21''.2$. I have accord-

ingly adopted this value; and I have assigned it to 1827, though perhaps it belongs rather to 1828; the assignment of it to 1828 would render the value of {observed diff. Dec.—diff. Dec. by the Downing-Elkin orbit} greater than that entered in the table.

Dunlop's diff. of Declination may be assigned to 1826.0.

On examining the note-books and other MSS. on which Richardson's Paramatta Catalogue is based, which the Assistant Secretary was kind enough to place before me, I found they supported the view that there were no measures taken of *both* α_1 and α_2 Centauri before the end of 1825 or beginning of 1826; and I came to the conclusion that, for the present purpose, no notice need be taken of the Catalogue, the results therein contained being simply Dunlop's measures, which are given, slightly modified, in his papers in the Society's *Memoirs*.

Fallows' diff. of Dec. must be considerably too large. This is rendered evident by finding the sectorial areas for the intervals between his epoch and those of subsequent observers. It is, of course, impossible to say what amount of error attaches to his diff. Dec., but it seems likely that the error reaches some 4" or 5". The circumstance is not surprising, since his telescope did not separate the close components of α Crucis, which are about 5" distant from each other. At the same time it is to be remembered that Fallows was a remarkably careful observer; and it would be a mistake to attribute to him an error to which the inferiority of his instrument did not render him liable.

It appears from the table that concurrent testimony is borne by all the observers, from Henderson backwards, that the differences of Declination afforded by the Downing-Elkin orbit are too small. In fact, the largest diff. of Dec. which that orbit will admit of is about 18"; while, judging from recorded observations, the diff. may be supposed to reach some 20". From this it seems to follow that the periodic time must exceed seventy-six years; and then, having regard to Feuillée's important observation in 1709, discussed in my former Paper, it appears probable that the period of α Centauri extends over eighty-six, or more, years.

Hampstead:

1886, March 3.

On the Orbit of 40 (α^2) Eridani. By J. E. GORE, M.R.I.A.

The star 40 (α^2) Eridani with its distant double companion forms a remarkable ternary system. As far as I know, the elements of the orbit have not hitherto been published. The close pair BC have described over 200° of its apparent ellipse since it was measured by Sir W. Herschel in 1783. By means of the graphical method described in the *Handbook of Double Stars* by Messrs. Crossley, Gledhill and Wilson, I have computed the orbit, and find the following elements:—

Elements of 40 Eridani (BC).

$$P = 139.0 \text{ years.}$$

$$\Omega = 146^\circ 20' (1880.0).$$

$$T = 1863.88.$$

$$\lambda = 354^\circ 23'.$$

$$e = 0.1362.$$

$$a = 5''.99.$$

$$\gamma = 76^\circ 20'.$$

$$\mu = -2^\circ.59.$$

From these elements we have the following formulæ:—

$$(1) \quad u - 7.80 \sin u = -2^\circ.59 \quad (t = 1863.88),$$

$$(2) \quad \tan \frac{1}{2}V = 1.146 \tan \frac{1}{2}u,$$

$$(3) \quad \tan (\theta_c - 146^\circ 20') = 0.23627 \tan (V + 354^\circ 23'),$$

$$(4) \quad \rho = 5''.99 (1 - 0.1362 \cos u) \frac{\cos (V + 354^\circ 23')}{\cos (\theta_c - 146^\circ 20')};$$

where u is the eccentric anomaly, and V the true anomaly for any epoch t , θ_c the position-angle, and ρ the distance.

The following table shows a comparison between the recorded observations and the positions computed by the above formulæ. The computed angles have been corrected for the effect of precession.

*40 Eridani (BC).**Comparison of Observations with Elements.*

Epoch.	Observer.	θ_0	θ_c	$\theta_0 - \theta_c$	ρ_0	ρ_c	$\rho_0 - \rho_c$
1783.13	Sir W. Herschel	326.7	329.93	-2.23	4-8	6.41	—
1825.12	Struve	287	292.28	-5.28	—	—	—
1850.94	O. Struve	156.6	156.56	-0.04	3.96	4.29	-0.33
1851.06	Dawes	160.0	156.44	+3.56	3 ±	4.29	—
1851.49	O. Struve	155.0	155.96	-0.96	3.87	4.37	-0.50
1853.64	"	155.4	153.67	+1.73	3.93	4.66	-0.73
1854.79	"	155.3	152.55	+2.75	4.13	4.78	-0.65
1856.80	"	152.9	150.73	+2.17	4.51	4.97	-0.46
1857.82	"	153.0	149.84	+3.16	4.40	5.03	-0.63
1864.80	Winnecke	147.6	144.18	+3.42	4.45	5.12	-0.67
1864.84	O. Struve	147.6	144.18	+3.42	4.45	5.12	-0.67
1865.89	"	143.8	143.28	+0.52	4.26	5.03	-0.77
1869.10	"	140.4	140.24	+0.16	4.46	4.79	-0.33
1872.56	"	140.6	136.86	+3.74	4.62	4.35	+0.27
1873.99	"	133.9	135.13	-1.23	4.27	4.09	+0.18
1874.10	"	135.7	135.02	+0.68	4.99	4.11	+0.88
1875.14	"	138.1	133.6	+4.5	3.80	3.89	-0.09
1877.84	Cin. Obs.	127.5	129.34	-1.84	4.36	3.43	+0.93
1877.86	Burnham	128.2	129.34	-1.14	3.92	3.43	+0.49
1879.05	"	125.4	127.0	-1.60	3.66	3.22	+0.44
1880.09	"	121.3	124.5	-3.2	3.28	2.99	+0.29
1880.95	"	122.0	121.5	+0.5	3.16	2.74	+0.44
1881.84		119.0	119.7	-0.7	3.53	2.62	+0.91
1883.00		119.2	115.6	+3.6	3.07	2.39	+0.68

The elliptical motion is, of course, probably somewhat perturbed by the attraction of the principal star, which, though very distant, is much larger, its apparent magnitude being about $4\frac{1}{2}$, while the components of the binary pair are 9 and 10.8.

Assuming the above elements, and the parallax of the star at $0''.223$ (as found by Prof. Asaph Hall), I have computed the following figures, which may be of interest.

Taking the Sun's mean distance from the Earth as unity, I find

Distance of 40 Eridani from the Earth	...	...	...	924955
Mean distance between the components, B C	...	...	...	26.86
Sum of masses of B C	}	...	...	1.003
Sun's mass = 1				

Some new Red and Orange-red Stars. By the Rev. T. E. Espin.

The observations of the stars were made with a 9-inch Calver Reflector equatorially mounted, and with a $17\frac{1}{4}$ -inch Calver reflector, equatorially mounted also, with driving clock, and circles reading in R.A. to 5 seconds, and in Declination to $1'$. Since September 24 the observations were made with the latter instrument. The power used was a sweeping power of 70. The first column gives the number continued from the list given in vol. iii. *Liverpool Astronomical Society's Journal*, p. 82; the second, the D. M. number; the third the approximate R.A. and Declination brought up to 1885; the fourth, Argelander's magnitude; the fifth and sixth, the observed mean magnitude and colour; the seventh, the number of nights on which each star was observed; the eighth, the night it was detected. An asterisk denotes that the star was previously observed by my friend, the late Rev. T. W. Webb. Certain orange stars have been included, either because they are finely coloured, or because of a neighbouring blue star—a combination of frequent occurrence, the reason of which is at present unexplained. Mr. Webb's observations, and my own, where there seemed any reason for giving them in detail, will be found in the notes.

Abbreviations: RR, very red; R, red; R¹, pale red; R², very pale red. Shades of orange-red and orange denoted in the same way, by ORR, &c., and O.

No.	D.M.	R.A. 1885.		Decl.	Magnitude.		Colour.	No. of Nights Obs.	Date.
		h	m		Arg.	Obs.			
33	54 ^o 116	0	30.6	+54 ^o 35.6'	7.8	8.5	R ²	1	1885. Dec. 4
34	39.167		38.3	+40 3.0	7.1	7.0	OR ²	3	Oct. 1
35	57.258	I.	12.5	+57 42.3	8.8	8.5	R	3	Dec. 2

No.	D.M.	R.A. 1885.	Decl.	Magnitude. Arg.	Obs.	Colour.	No. of Nights Obs.	Date.
36	57°320	^h 25 ^m 7	+ 57 48.2	6.5	6.0	OR ¹	1	^{1885.} Dec. 2
37	60°327	37.8	+ 60 27.2	8.5	8.5	RR	1	Dec. 2
38	60°335	38.2	+ 60 24.8	9.4	9.5	R ¹	1	Dec. 2
39	59°466	II. 11.3	+ 59 29.0	6.7	6.6	O ³	2	Dec. 2
40	58°445	12.0	+ 59 8.1	8.8	8.5	R	2	Dec. 2
41	52°637	43.6	+ 52 32.4	7.0	7.5	OR ³	1	Nov. 16
42*	24°570	III. 41.2	+ 24 37.9	7.0	var.?	OR ¹	2	Nov. 5
43*	25°599	50.6	+ 25 9.4	6.8	7.0	O ²	1	Nov. 17
44	2°640	57.3	+ 2 44.4	7.8	6.5	OR ¹	1	Dec. 7
45	12°547	57.9	+ 12 11.2	7.7	7.5	R ¹	1	Dec. 9
46	34°863	IV. 14.0	+ 34 17.6	7.5	8.0	OR	1	Nov. 30
47	34°874	16.8	+ 34 58.7	7.2	8.0	OR ¹	1	Nov. 30
48	6°865	V. 5.9	+ 6 42.7	7.9	7.8	R	1	Dec. 16
49	45°1084	9.3	+ 46 0.0	7.8	var.	OR ¹	7	Oct. 9
50	35°1046	11.5	+ 35 40.0	8.9	8.5	RR	3	Nov. 20
51*	—	12.5	— 8 22.2	—	8.5	ORR	1	Dec. 7
52	29°897	19.8	+ 29 49.2	8.0	8.0	RR	3	Nov. 14
53	—	19.6	— 10 27.2	—	6.0	OR ¹	1	Dec. 7
54	32°1030	26.2	+ 32 39.8	7.0	6.5	OR ²	2	Nov. 17
55	50°1225	38.3	+ 50 2.4	7.1	7.0	OR ¹	1	Nov. 30
56	44°1288	40.2	+ 44 47.9	9.2	8.6	RR	8	Nov. 5
57	32°1109	44.0	+ 32 5.7	6.6	6.0	OR	1	Nov. 16
58	53°962	46.3	+ 53 26.1	8.0	8.2	R	2	Nov. 17
59	54°971	50.3	+ 54 32.6	7.0	7.0	O ¹	2	Nov. 17
60*	44°1331	51.6	+ 44 58.9	8.1	8.0	O ²	2	Oct. 24
61	28°966	52.8	+ 28 7.0	6.9	7.5	O ²	2	Nov. 14
62	33°1290	VI. 9.9	+ 33 14.9	9.1	8.5	RR	2	Dec. 13
63	Anon.	41.5	+ 0 48.4	—	9.6	RR	4	Dec. 14
64	—	51.0	— 3 2.4	—	8.0	R	1	Dec. 16
65	—	VII. 11.8	— 23 6	—	7.0 var.?	O	1	Dec. 1
66	54°1337	IX. 48.5	+ 54 48.2	7.0	7.5	OR ¹	1	Dec. 13
67	27°2509	XV. 29.7	+ 26 54.6	8.2	8.0	R ¹	4	June 30
68*	24°2901	33.3	+ 24 53.8	7.4	7.0	OR ¹	1	June 30
69	35°2828	XVI. 26.8	+ 35 28.7	7.0	6.0	OR ²	2	June 30
70	35°2911	59.4	+ 35 34.2	6.5	6.5	OR ²	2	June 30
71	14°3201	XVII. 6.7	+ 14 38.3	7.3	7.0	O ¹	1	July 13
72	17°3213	12.8	+ 17 14.3	7.5	8.0	O	1	July 13
73	17°3225	15.6	+ 17 10.2	7.8	7.0	R ¹	1	July 13

No.	D.M.	R.A. 1885.	Decl.	Magnitude. Arg.	Obs.	Colour.	No. of Nights Obs.	Date.
		^h ^m	[°] [']					^{1885.}
74	12°3256	30°5	+12 6'6	7.0	7.0	R ²	1	July 9
75	35°3006	30°6	+35 57'1	7.5	7.8	OR ³	2	June 30
76	36°2937	42°8	+36 7'5	6.5	6.7	OR ²	2	June 30
77	36°2942	43°9	+36 35'7	6.5	6.7	R ²	2	June 30
78	12°3305	45°3	+11 59'4	6.4	7.0	O ¹	1	July 9
79	1°3524	46°2	+ 1 8'2	6.8	7.5	R ²	1	July 8
80	1°3528	46°7	+ 1 20'5	6.0	7.0	R ¹	1	July 8
81	17°3520	XVIII. 12°7	+17 55'4	7.5	7.0	R ²	1	July 13
82	38°3219	30°2	+38 20'9	7.3	7.0	OR	1	Sept. 25
83*	37°3180	33°6	+37 40'8	7.0	6.5	R ²	3	June 30
84	44°2961	37°3	+44 51'7	8.6	8.5	R ²	1	July 25
85	44°2969	38°8	+44 51'6	9.1	9.0	R ²	1	July 25
86*	39°3505	39°4	+39 11'1	6.5	7.0	OR	1	July 23
87	36°3339	53°1	+36 18'9	7.0	7.0	OR ¹	1	June 30
88	23°3543	58°8	+23 10'8	8.0	8.5	R ²	2	July 2
89	38°3445	XIX. 4°3	+38 58'4	6.9	7.7	O ²	3	July 8
90	38°3493	10°0	+38 46'5	7.7	7.7	OR ³	3	July 4
91	38°3518	13°2	+38 46'6	6.7	6.9	R ²	1	June 30
92	37°3403	13°5	+37 23'8	8.0	8.0	R ²	2	June 30
93	17°3940	16°5	+17 26'4	9.5	var.	RR	3	Sept. 27
94	49°2999	21°5	+50 0'4	7.5	7.0	R ¹	2	July 5
95	9°4114	23°0	+ 9 23'6	8.1	8.0	OR ¹	3	July 8
96	25°3884	30°4	+25 44'9	8.2	8.3	OR ²	6	July 5
97	23°3706	31°0	+23 35'7	8.0	8.0	R ¹	1	July 4
98*	17°4043	35°0	+17 37'7	8.2	8.0	O ²	2	July 20
99	37°3577	38°7	+37 24'8	7.9	8.0	OR ²	4	June 30
100*	—0°3386	39°6	— 1 1'7	9.3	8.0	O	1	Sept. 25
101	40°3866	40°1	+40 25'9	6.3	6.0	OR	1	July 23
102	10°4046	41°1	+10 10'8	8.3	8.0	OR ³	3	July 8
103	35°3784	41°2	+35 47'7	9.1	9.5	R ²	2	July 2
104*	9°4264	42°4	+ 9 45'2	8.1	8.0	O ¹	2	Sept. 24
105	38°3780	46°4	+38 25'5	5.5	6.0	O	1	July 23
106	37°3636	46°6	+37 31'4	7.0	7.0	R ²	2	June 30
107	25°4006	47°5	+25 40'0	8.5	8.5	OR	2	Oct. 5
108	44°3295	53°5	+44 44'5	9.0	8.0	R ²	1	July 25
109*	17°4185	54°9	+17 17'5	7.5	7.5 var.?	R ¹	1	July 9
110*	37°3744	59°5	+38 0'1	7.2	8.5	R ²	2	July 12
111	14°4209	XX. 5°2	+14 12'4	7.5	8.0	O ²	1	Sept. 27

No.	D.M.	R.A. 1885.	Decl.	Magnitude. Arg.	Obs.	Colour.	No. of Nights Obs.	Date. 1885.
112	38°4003	^h 14 ^m 8	+38° 38' 4	6.8	7.0	OR ^s	2	July 12
113	39°4130	14.5	+39 52.1	8.0	8.0	OR ¹	1	Oct. 1
114	39°4152	17.5	+40 4.7	8.8	9.0	R ¹	8	July 8
115	53°2384	17.5	+53 13.3	6.5	7.0	R ¹	1	July 5
116*	39°4172	20.6	+39 46.5	7.5	8.0	OR ¹	2	July 2
117*	15°4172	23.8	+15 52.8	8.3	8.5	R	1	July 9
118	39°4208	24.6	+39 35.7	9.2	var.	RR	17	July 9
119	45°3271	42.9	+45 37.6	8.8	8.6	RR	4	July 25
120	45°3289	44.9	+45 25.6	8.6	8.5	OR	3	July 25
121	50°3209	46.0	+50 20.9	7.3	7.5	R ¹	1	July 5
122	49°3386	47.2	+49 41.5	6.8	7.5	R ¹	2	July 5
123	45°3349	54.0	+45 47.8	8.1	8.0	RR	2	Dec. 15
124	47°3321	XXI. 6.5	+47 11.2	7.8	7.5	OR ^s	4	July 25
125	49°3499	14.8	+49 34.9	7.0	6.5	OR ¹	1	Oct. 27
126	62°1921	14.8	+62 26.3	8.7	9.0	OR	3	Nov. 5
127	48°3348	16.3	+48 51.7	8.2	8.5	R ²	1	Oct. 27
128	61°2134	22.8	+62 4.5	8.8	8.7	RR	5	Oct. 27
129	48°3470	37.7	+48 40.2	8.8	9.0	R	1	Oct. 27
130	70°1193	38.6	+70 15.7	7.0	8.5	OR ¹	1	Dec. 2
131	57°2396	42.6	+57 32.0	7.5	8.7	ORR	1	Dec. 2
132	62°1997	49.6	+62 39.5	9.2	8.5	R ¹	1	Nov. 5
133	65°1691	54.2	+65 36.2	6.5	6.5	OR ^s	1	Nov. 5
134	38°4701	XXII. 6.3	+39 8.5	7.2	7.5	R ²	1	July 23
135	56°2793	26.0	+56 24.3	8.0	7.7	OR	4	Oct. 24
136	57°2562	30.2	+57 34.6	7.5	7.5	OR ²	8	Oct. 24
137	57°2568	32.4	+57 49.9	7.3	var.	OR ¹	8	Oct. 24
138	42°4548	52.2	+42 23.5	6.8	7.0	OR ¹	1	Nov. 30
139	57°2674	57.6	+57 37.3	8.4	8.5	R ¹	1	Dec. 2
140	58°2534	57.8	+58 57.4	8.0	8.0	R ¹	1	Dec. 2
141	48°4051	XXIII. 21.5	+48 52.9	9.3	9.0	OR	2	Nov. 16

Notes.

35. Closely f. H VII. 42, a little N. Mr. Webb, 1877, Dec. 14, observed a star 8.0 30' S. a little f. I can find no red star in this place now. The reading of Mr. Webb's circle is given, leaving no doubt concerning the correctness of the assigned place.

39. Remarkable pair. Two equal stars, second decided green; 10.5 comes makes a triangle.

42. November 5, 8.0; November 17, 6.5. Webb's observation, 1876, January 1, orange ruby, 7.0. November 17, confirmed as to colour. 1878,

November 28, orange, but did not particularly attend to magnitude; but I do not think it could have been as large as 7.0.

43. Webb's observation, 1878, November 28, very pale ruby.

44. Blue star, 6.7, closely N.

47. Blue star, 20 sec. p., 8.0 magnitude.

48. Fine wide pair, 7.8 R, 8.0, O.

49. Near Capella. October 9, 8.0; October 24, 6.0; November 5 and 14, 7.3; ($46^{\circ}989 = 7.1$, $46^{\circ}985 = 7.7$); November 28, 7.6; November 30 and December 14, 7.4.

51. Webb's observation, 1878, January 25, pale ruby, 8.5.

54. Blue star, 6.5, near.

58. Blue star, 9.0, near.

60. Webb's observation, 1874, March 26, 9.3, very pale ruby.

63. A remarkably red star f. + $0^{\circ}1600$ by $6\frac{1}{2}$ seconds.

64. Place only approximately found from B 147.

65. λ 3945 Canis Majoris. 1884, February 10, 6.5, red; 7.0, remarkably blue; 1885, December 1, 7.0, orange; 8.0, blue, very fine. The large star is probably variable.

68. Webb's observation, 1877, September 5, 8.0, orange ruby.

83. Webb's observation, 1882, August 10, pale ruby, 9.0.

86. Webb's observation, 1872, May 31, pale orange-red.

93. Compared with $17^{\circ}3938 = 9.0$. September 27, 9.5; October 27, 9.5. On December 7 I was much astonished at finding it fully 8.5.

96. A triangle. $25^{\circ}3883$ is at the apex. The shades of colour in these two stars very perplexing. The latter once blue; at other times orange, and orange red. Its mean magnitude is 8.4.

98. Webb's observation, 1876, October 14. Very pale orange or ruby, 9.0; 1884, September 5, pale ruby, 9.0.

99. Fine field. Star p. 8.0, very blue.

100. Webb's observation, 1882, September 15, orange, with 10, pale blue, a few minutes p.

104. Webb's observation, 1879, September 3, 8.5, 9.5, $300^{\circ} \pm 50''$, pale orange-red, pale yellow. On September 24, 25, I found the colours orange and blue, the blue being especially remarkable.

109. In a glorious field, the lucida $6\frac{1}{2}$ orange. Webb's observation, 1880, August 9, beautiful wide group, with 6.0 pale orange. 1881, October 14, fine group attendant on 7.0, pale orange, with 9.0, pale orange, or orange red, S.

110. λ 1470 comes 10.2, very blue. Webb's observation, 1879, September 25, 8.5, 9.5, pale orange-red; pale blue.

111. Comes 12.0, $20'' \pm$.

116. Webb's observation, 1876, August 30, $8\frac{1}{2}$, orange ruby.

117. 8.0, blue, near. Webb's observation, 1873, September 12, ruby, 9.0. Comes 14 NP. 1875, October 2, pale ruby, 8.5. Two faint comites Np.

118. Compared with $39^{\circ}4210$, 8.0, and $39^{\circ}4206$, 8.8, clear blue. On the night of its discovery it was fully 7.9 out of focus, since which time it has irregularly diminished to 9.0. The colour is very fine. The Rev. T. W. Webb swept over this region repeatedly, but has no note of it.

124. A blue star near 7.3 magnitude.

133. A pale blue, 6.5, near.

137. Variable in some short period between 7.0 and 8.0. No. 136 used as a comparison star = 7.5. The following are all my observations of it:—

1885, Oct. 24	8.0	1885, Dec. 5	7.6
	27 7.0		7 7.6
Nov. 16	7.2	11	7.2
Dec. 2	7.2	15	7.1

The New Star in Orion photometrically and spectroscopically observed at the Oxford University Observatory. By Prof. C. Pritchard, D.D., F.R.S.

Date of Observation.	Mag. of Nova when compared with <i>Polaris</i> = 2'05.	57 <i>Orionis</i> = 6'03.	Adopted Mean Mag. of Nova.	Notes.
1885.				
Dec. 23	6'49	6'43	6'46	
28	6'42	6'42	6'42	Fine night.
29	6'45	6'32	6'39	Very fine night.
1886.				
Jan. 2	6'47	6'39	6'43	Fine night ; slight fog.
5	6'71	6'76	6'74	Fine night.
8	6'80	6'63	6'72	Fine night ; but bad definition.
11	6'69	6'74	6'72	Fine night ; haze low down.
18	6'92	6'83	6'87	Sky very fine.
26	6'77	6'90	6'82	Fine night.
Feb. 7	7'02	6'86	6'94	Bad definition ; fine night.
23	6'93	7'13	7'03	Very fine night.
March 9	7'22	7'05	7'14	Fine nights ; with low definition.
10	7'05	7'13	7'09	

Colour and Spectrum.—On December 23 the colour of the star was noted to be red-orange ; spectrum columnar and four bands noticeable with Vogel eyepiece spectroscope. On December 29, in better definition, two other bands were seen in the red. On January 8 bright lines were specially looked for, but it was impossible to say whether any definite bright lines existed. The red colour has diminished considerably during the time the star has been watched, and is now not at all conspicuous.

I think that as far as the foregoing magnitude of the *Nova* are concerned, the accuracy is considerable ; the main result being that from the time of its first observation here to the present, the star has decreased in brightness by about half a magnitude, viz. about 6'5 to 7'0 mag.

With regard to perhaps the more important question of the character of the spectrum, what is said above—viz. that it is seen here with six bands—must be read with the limitations due to the character of the small spectroscope employed ; the larger and more delicate instrument belonging to the Observatory being at present at Greenwich. Still even with the largest forms of spectroscopes at the Royal Observatory and at Dun Echt the apparently contradictory results are perplexing.

Oxford University Observatory :
March 11, 1886.

Observations of the New Star in Andromeda, made at Mr. Wigglesworth's Observatory with the 15.5-inch Cooke Refractor.
By J. Gerh. Lohse.

When the intelligence of the discovery of the new star in *Andromeda* was received, it was determined to connect the star micrometrically with some neighbouring stars, to compare its brightness with that of suitable stars, and to examine the spectrum as far as the instruments might allow.

The micrometric observations were made with a micrometer kindly lent by Lord Crawford. It was constructed by Merz, possesses only one micrometer screw, and has three movable wires and a set of fixed wires. A fine movement can be given to the whole micrometer by two screws in the adapter—an arrangement which has proved very convenient.

The observations of the old nucleus and of the 11th mag. star in the nebula are given singly; in the case of the other stars, however, the final result only is given. The corrections for refraction have been applied.

Measures of the Old Nucleus from the New Star.

1885.	Pos.	Dist.
Sept. 3	76°50	16''12
4	75°46	15'73
6	*	16'59
6	77°10	16'22
6	74°80	17'24
9	75°60	16'02
29	76°30	16'48
	75°96	16'343

$$\Delta\alpha = +1^{\circ}393$$

$$\Delta\delta = +3''96$$

1885.	Pos.	Dist.
Nov. 30	*	15''21
	76°12	14'94
	76°24	14'95
	76°18	15'033

$$\Delta\alpha = +1^{\circ}283$$

$$\Delta\delta = +3''59$$

* The first settings in Pos. on Sept. 6 and Nov. 30 were rejected at the telescope.

Measures of the 11th Mag. Star.

1885.	Pos.	Dist.
Oct. 1	262°07	108''27
	262°10	109°04
	—	109°80
	262°00	108°95
	---	108 28
	—	108°20
	262°06	108°76
$\Delta\alpha = -9^{\circ}46$		$\Delta\delta = -15''00$
1885.	Pos.	Dist.
Nov. 30	261°58	108''67
	261°60	109°38
	261°59	109°03
$\Delta\alpha = -9^{\circ}48$		$\Delta\delta = -15''95$

The following table contains the estimated magnitudes of the stars, measured from the new star, the position-angles and distances, the differences of R.A. and Declination, and the date on which the observations were made.

Mag.	Pos.	Dist.	$\Delta\alpha$	$\Delta\delta$	Date.
10	294 4'97	382''82	— 30°72 ^s	+ 156''21	1885. Oct. 6
13	252 28'55	223'98	— 18°76	— 67'44	Oct. 1
10.2	345 11'78	439'53	— 9°88	+ 424'93	Oct. 1, 5, 26
11	341 31'08	292'32	— 8°14	+ 277'24	Oct. 1, Nov. 30
12.8	351 40'97	323'53	— 4°11	+ 320'12	Oct. 26
11.4	354 42'10	429'69	— 3°49	+ 427'86	Oct. 5
11.4	355 49'30	373'39	— 2°39	+ 372'39	Oct. 5
11.6	171 45'33	154'20	+ 1°94	— 152'62	Oct. 1, Dec. 1
11	156 46'20	230'28	+ 7°98	— 211'60	Oct. 1, Nov. 30
9.7			+ 55°52	+ 390'16	Oct. 29
11			+ 85°73	+ 248'98	Oct. 29
9			+ 123°24	+ 168'42	Sept. 4
10			+ 202°60	+ 397'49	Oct. 29

The other observations are given in chronological order :—

Sept. 3.—The spectrum is continuous, no lines could be distinguished in it with the Browning and McClean spectroscopes. The bright C line was very well seen in γ Cassiopeia.

The new star is one magnitude larger than the two 9th mag.

stars north of M 32, but fainter than the stars B.-W.₂, $\alpha^h 1057$ and $\alpha^h 1062-3$.

Sept. 6.—The colour of the new star is yellow like that of several Bessel-Weisse stars in the neighbourhood, viz. B.-W.₂ $\alpha^h 896$, $\alpha^h 953$, $\alpha^h 965$, $\alpha^h 1062$. The star is of the same brightness as B.-W.₂, $\alpha^h 953$, if anything a little brighter.

With a view to ascertain whether the appearance of the new star had produced a sensible alteration in the nebula, a small piece of paper was stuck to the field lens of a positive eyepiece, and the image of the new star placed behind it. The glare of the bright star being thus eliminated, the nebula, with the exception of the immediate neighbourhood of the new star, was very well seen, and appeared symmetrically arranged round the old nucleus, very much in the same way as I had known it before. Also without the use of a piece of paper on the eyepiece it was not difficult to see that the central part of the nebula is round and regularly arranged, with regard to the old nucleus as centre. The new star, therefore, as might have been expected, does not seem to have affected the form and distribution of matter in the nebula at all.

Sept. 9.—The new star in *Andromeda* is still as bright as B.-W.₂, $\alpha^h 953$, but certainly not brighter. The colour is perhaps a little more reddish than formerly, but I am not quite certain about it. The spectrum is still continuous, but the part from F to about midway between F and G is fainter than in the spectra of neighbouring stars. In consequence of that, the spectrum near G appears comparatively brighter, but it does not seem to be brighter than the corresponding part of the spectrum of B.-W.₂, $\alpha^h 953$, which has about the same brightness. The position of the fainter part in the spectrum depends on estimation only, there being no means for measuring the wave-length.

Sept. 12.—The new star is now decidedly fainter than B.-W.₂, $\alpha^h 953$, and only one- or two-tenths of a magnitude brighter than the two stars north of M 32. The spectrum is continuous, and as long as that of D. M. + 40° 145, if not longer. Much attention was paid to the red end of the spectrum, and repeated comparisons of the two spectra convinced me that this part of the spectrum is quite as much developed in the new star as in D. M. + 40° 145. The observations were made with a McClean prism held in front of the eyepiece, and are only estimations.

Oct. 26.—The new star is of the same magnitude as the 10.2 mag. star in pos. $345^\circ 21$, and dist. $439'' 53$.

Nov. 28.—The new star is of the same brightness as the 11th mag. star preceding it in the nebula.

Dec. 1.—With a magnifying power of 196 the new star appears .1 mag. brighter than the preceding star, but with a power of 127 it appears decidedly fainter, owing to the apparent increase of brightness of the nebulosity around it.

The determinations of the distance of the old nucleus from the new star seem to possess a special interest; for the observa-

tions made on November 30 give a smaller value for this distance than any of the observations made in September. This result is partly confirmed by the observations of the 11th mag. star in the nebula, sp. of the new star. The distance found on November 30 is a little larger than that obtained on October 1, as it ought to be if the distance between the nucleus and the 11th mag. star had remained unaltered; the difference, however, in this case is not so great.

The observations of Dr. Engelmann, published in *Ast. Nach.* No. 2683 and 2704, give similar results. The earlier series gives

Nova to old nucleus	...	...	...	...	16 ^{''} 33
Nova to 11th mag. star	...	...	...	...	109 ^{''} 72

while the distances derived from later observations are

Nova to old nucleus	...	...	...	...	15 ^{''} 96
Nova to 11th mag. star	...	...	...	...	109 ^{''} 98

The difference between the measures of the old nucleus is also in this case the larger one.

Although there are great discordances even between observations made on the same night, it seems difficult to explain the differences between the earlier and later observations entirely by errors of observation. The fact that two observers altered their mode of observing at the same time and in the same direction, while observing the same objects, seems very remarkable, unless there was some real change in the objects. If we assume that the new star has a large proper motion in the direction towards the nucleus, the greater part of the discordances vanishes. Unfortunately, no more observations can be obtained, the star having disappeared in the surrounding nebulosity.

Mr. Wigglesworth's Observatory, Scarborough:
1886, March 10.

Observations of Comets d, 1885 (Fabry), and e, 1885 (Barnard), made at the Royal Observatory, Greenwich.

(Communicated by the Astronomer Royal.)

The observations were made with the East or Sheepshanks Equatorial, aperture 6·7 inches, by taking transits over two cross wires at right angles to each other, and each inclined 45° to the parallel of Declination.

Comet d, 1885.

Greenwich Mean Solar Time. 1886.	Observer.	δ - * R.A.	Corr. for Par. and Refract. in R.A.	δ - * N.P.D.	Corr. for Par. and Refract. in N.P.D.	No. of Comp.	Apparent R.A.	h m s	Apparent N.P.D.	Comp. Star.
March 7 7 28 52	H. T.	+ 3 21' 30	+ 0' 31	- 5 25' 2	- 4' 1	1	23 19 41' 87	58 43 15' 8	a	
7 31 33		- 0 30' 70	+ 0' 24	+ 7 27' 0	- 2' 5	2	23 19 44' 12	58 43 20' 2	b	
7 42 4		- 1 14' 45	+ 0' 33	- 9 31' 3	- 4' 6	2	23 19 39' 44	58 43 8' 9	c	

Comet e, 1885.

March 7 7 59 3	H. T.	- 0 29' 62	+ 0' 22	+ 1 5' 1	- 3' 3	5	1 54 42' 04	67 10 33' 8	d	
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Mean Places of Comparison Stars.

Star's Name.	R.A. 1886°.	N.P.D. 1886°.	Authority.
(a) 64 <i>Pegasi</i>	23 16 21' 07	58 48 42' 6	9-year Catalogue.
(b) W. B. (2) XXIII. 380	23 20 15' 38	58 35 53' 2	Weisse's Bessel (2).
(c) Lalande 45897	23 20 54' 36	58 52 42' 2	Lalande.
(d) Arg. Zone + 22° No. 296	1 55 11' 86	67 9 26' 7	Rümker.

Notes.

- (d) Comet bright, with nucleus.
 The observations are corrected for parallax and refraction. The initials H.T. are those of Mr. Turner.
Royal Observatory, Greenwich: 1886, March 12.

*Observation of the Conjunction of Saturn and μ Geminorum,
January 10, 1886. By John Tebbutt.*

A set of differential measures of *Saturn* and the bright clock-star μ *Geminorum* was obtained here about three hours after the conjunction in Right Ascension on the 10th instant. The position filar micrometer, properly oriented, was employed on the $4\frac{1}{2}$ -inch Equatorial, the transit of the planet's first limb and the star being observed across one of the close position-threads, and differences of Declination measured between the star and the planet's south or visible limb. The definition was generally fair, but the southern limb was shaded, and difficult to bring into accurate contact with the declination thread. The images, too, were occasionally rather unsteady. The following table exhibits all the measures obtained. The sidereal times of transit of the limb and the differences of the R.A. of the limb and star have been corrected by the addition of $0^s.75$, the time of the semi-diameter passing the meridian, and the differences of Declination by the addition of $9''.2$, the polar semi-diameter.

Windsor Sidereal Time.			Planet's Centre—Star.	
h	m	s	Diff. R.A.	Diff. Declin.
			s	"
4	33	50.83	-2.40	+26.3
4	37	18.98	-2.25	+28.4
4	39	44.53	-2.40	+29.9
4	42	2.33	-2.50	+28.8
4	44	44.68	-2.60	+28.4
4	46	9.58	-2.15	+28.3
4	48	13.83	-2.65	+27.9
4	50	34.08	-2.70	+28.7
4	52	58.83	-2.75	+27.8
4	55	30.53	-2.75	+28.4
5	6	13.83	-2.90	+29.0
5	9	29.33	-2.75	+27.3
5	12	10.08	-2.85	+28.3
5	16	2.83	-3.00	+29.5
5	18	29.33	-3.00	+28.5
5	20	19.83	-2.95	+29.7
5	22	11.33	-3.15	+29.4
5	23	41.33	-3.25	+29.9
5	25	50.03	-3.05	+23.2
5	27	59.08	-3.25	+29.0
Means ...	5	1 40.56	-2.77	+28.6
Correction for Parallax	...	...	-0.02	-0.9
Adopted App. R.A. and Dec. of Star	6 ^h 16 ^m	5.15	+22°	34' 5.2
Concluded Geoc. App. R.A. and Dec. of Planet ...	6 16	2.36	+22	34 32.9

The local mean time corresponding to this position is $9^h 42^m 08^s.35$. The planet and star were observed differentially the same evening by means of the 3-inch Transit instrument, the resulting apparent R.A. of the planet's centre being $6^h 16^m 18^s.18$. The evenings preceding and following the conjunction were cloudy. The star during the above observations appeared remarkably red.

Windsor, N.S. Wales :
1886, January 19.

On the Connection between Photographic Action, the Brightness of the Luminous Object and the Time of Exposure, as applied to Celestial Photography. By A. C. Ranyard.

The following experiments have been made with commercial dry plates by various makers. My object in the first instance was to obtain a comparison between the sensitiveness of the eye and the sensitiveness of the photographic film, for detecting small differences of illumination. With the eye a difference of one-sixtieth in the intensity of the illumination of two adjacent fields can be detected when the illumination is not too brilliant or too faint, and when the illuminated areas are of sufficient extent.

Fechner has shown that there is a physiological connection between the brightness of the illuminated fields and the difference of illumination which can be detected. He estimated that under the most favourable conditions a difference of one per cent. of illumination could be detected, and from the experiments of Helmholtz and others, there is no doubt that a difference of one-sixtieth can be recognised with certainty.

In order to make such a comparison, successive exposures of equal duration may be made on adjacent parts of the same plate, and the source of light removed through a measured distance between the exposures; or, if a connection can be established between the density of the photographic trace impressed upon the plate and the duration of the exposure, different parts of the plate may be exposed for different periods without moving the source of light, a course which greatly simplifies the experiment.

In order to test in a rough manner whether a light shining on a plate for a unit of time produced the same effect as a light of double the intensity shining for half the unit of time, one-half of a Wratten and Wainwright 'extra sensitive' plate was exposed to the light of a paraffine candle shielded from currents of air at a distance of five feet for a period of forty seconds, and the other half of the plate was exposed to the light of two similar candles for a period of twenty seconds. On developing the two halves of the plate appeared to be of about the same

darkness. This experiment was repeated with different modes of development, but whether the developing process was carried so far as to cause the tints to be very dense and opaque, or whether the development was manipulated so as to give faint tints, the two halves of the plate appeared of about the same density.

In order to carry this experiment further, an opaque screen was made, corresponding to the size of the photographic plates experimented with. A quarter of the screen was cut away, so that by placing the screen in front of the plate and turning it round, four successive exposures of areas touching one another could be made upon the same plate.

A Wratten and Wainwright 'extra sensitive' plate was exposed in this manner to the light of a candle, protected from currents of air, so that

the 1st quarter of the plate was exposed for 18 secs. to the					
				candle at a dist. of 2 feet.	
„ 2nd	„	„	„	exposed for $40\frac{1}{2}$ secs. to the	
				candle at a dist. of 3 feet.	
„ 3rd	„	„	„	exposed for 72 secs. to the	
				candle at a dist. of 4 feet.	
„ 4th	„	„	„	exposed for $112\frac{1}{2}$ secs. to the	
				candle at a dist. of 5 feet.	

The exposures were made with as great accuracy as possible, the driving clock of my telescope, which can be made to tick at periods of $1\frac{1}{2}$ sec., being used to measure the exposures. On developing the plate, it was found that all four quarters of the plate appeared about equally opaque. It will be noticed that the durations of the exposures are inversely as the square of the distance of the source of light. Several other plates were exposed with longer and shorter periods of exposure, varying inversely as the square of the distance of the candle. The plates were always developed by being entirely immersed in the developing solutions, so that all parts would presumably be equally acted upon. In every instance the four quarters of the plate are so nearly equal in density that it is difficult to decide with certainty which is the darkest.

In one of the longer exposures, where the four quarters of the plate were exposed for 25 minutes, 9 minutes, 4 minutes, and 1 minute, at distances of 15 feet, 9 feet, 6 feet, and 3 feet respectively, there is a slight difference of density, perhaps due to unequal burning of the candle, but the difference is so slight that a friend, to whom I showed this plate, selected the two upper quarters as being less dense than the two lower quarters, and when I removed the plate and turned it upside down, on presenting it to him a second time he again chose the two upper quarters as less dense than the two lower quarters.

These experiments seem to prove that for faint illumination,

such as that derived from a candle, the following law of photographic action is either true, or so approximately true, that for all ordinary purposes the deviations from the law, if any, may be neglected.

The photographic trace left upon a plate is directly proportional to the intensity of the light, and to the duration of the exposure.

Having satisfied myself with regard to this law, I proceeded to apply it to testing the sensitiveness of commercial dry plates by various makers to slight differences of illumination. The plates were placed in dark slides and exposed in steps by withdrawing the shutter at intervals of seven and a half seconds, so that a narrow band across the top of the plate was exposed for seven and a half seconds; a band of similar width immediately below it was exposed for fifteen seconds; the band below this was exposed for twenty-two and a half seconds, and so on to the bottom of the plate.

On some of the commoner plates when developed only six steps can be counted. The density of the photographic action increases gradually to the bottom of the plate, but the places where the shutter has stopped cannot be recognised by any sudden change in the density after the sixth step.

I was able to count the greatest number of steps on a Wratten and Wainwright 'extra sensitive' plate exposed to the light of a candle at a distance of 4 feet. On this eighteen steps could be counted with certainty, and possibly nineteen when the plate was examined against a background of clear sky. The following table gives the greatest number of steps which I was able to count on plates by various makers:—

Fry and Son's (Kingston) Dry Plate.

Exposed to the light of a candle at a distance of 4 feet:
duration of exposures $7\frac{1}{2}$ s., 15 s., $22\frac{1}{2}$ s., 30 s., &c.
8 steps.

Rouch's (Extra Sensitive) Plate.

Exposed to the light of a candle at a distance of 4 feet:
duration of exposures $7\frac{1}{2}$ s., 15 s., $22\frac{1}{2}$ s., 30 s., &c.
8 steps.

Ealing Plate (50 Extra Sensitive).

Exposed to the light of a candle at a distance of 4 feet:
duration of exposures 6 s., 12 s., 18 s., 24 s., &c. 9 steps.

Derby Dry Plate Co. (Extra Rapid).

Exposed to the light of a candle at a distance of 5 feet:
duration of exposures 9 s., 18 s., 27 s., 36 s., &c.
12 steps.

Wratten and Wainwright (Extra Sensitive).

Exposed to the light of a candle at a distance of 4 feet:
 duration of exposures $7\frac{1}{2}$ s., 15 s., $22\frac{1}{2}$ s., 30 s., &c.
 18 (query 19) steps.

Thus the Wratten and Wainwright plate would not register a difference between the illumination given by 20 and 21 candles; and the difference of density of the photographic tint produced by the illumination of 19 and 20 candles was only recognised with difficulty and doubtfully. The photographic plate is therefore much less sensitive than the eye for detecting small differences of illumination. Prof. W. H. Pickering has been making some experiments with American dry plates, and finds that they will not show a difference of less than 5 per cent. of illumination. At first I thought that I could detect the position of the shutter up to some 30 steps, but on examining the plates more closely I found that there was a faint dark line across the plate wherever the shutter stopped. The dark line seemed to be due to reflection of light from the edge of the shutter; but when a little metal shade was made which threw a shadow on the edge of the shutter, as it was drawn up and down the dark line could not be detected, and the utmost number of steps counted was 19.

During a total solar eclipse the corona is not seen till about a minute or at most a minute and a half before totality commences, and observers seem to concur that it dies away in the increasing illumination as rapidly after totality; that is, all trace of the corona is lost when the thickest part of the Sun's crescent is less than a minute across. Taking into account the rapid decrease of light towards the Sun's limb, we shall be much within the truth in estimating that the corona is not seen till the illumination of the atmosphere about the Sun's place is less than one per cent. of the illumination of the atmosphere about the uneclipsed Sun. If the corona becomes visible when the illumination of the atmosphere is reduced to a brightness of thirty times the brightness of the corona, these observations would indicate that the brightness of the illuminated atmosphere round the uneclipsed Sun is at least 3,000 times as great as the brightness of the corona, and that unless the light of the corona is altogether of a different quality from that derived from the uneclipsed Sun, there is no chance of photographing the corona under ordinary daylight conditions. Unfortunately the spectroscopic photographs of the coronal light taken during eclipses, show that the monochromatic light of the corona (though it seems to differ in amount from eclipse to eclipse) never bears any large proportion to the continuous spectrum of the corona, or solar spectrum dispersed by the corona, as it should more properly be called. For the dark lines in the background of continuous spectrum, which recent observers believe that they have identified with certainty with the dark lines of the ordinary solar spectrum, lead to the sup-

position that the continuous spectrum of the corona is mainly due to dispersed solar light. If the light is dispersed by particles which are large compared with the wave-length of light, the relative intensity of different parts of the spectrum will not be affected by the dispersion, and there is no chance of photographing the corona under ordinary daylight conditions except by isolating and photographing the monochromatic images which bear so small a proportion to the general light of the corona. There is some evidence, though I do not look upon it as conclusive for all photographic processes, that the position of the maximum of photographic activity in the coronal spectrum does not differ materially from the position of the maximum of photographic activity in the ordinary solar spectrum. The position of the continuous spectrum of the corona relatively to the position of the bright coronal and prominence lines which have been identified in the eclipse photographs shows that the distribution of photographic action in the coronal spectrum does not differ very materially from the distribution of the photographic action in the ordinary solar spectrum.

The Great Shower of Andromedes, 1885. By T. W. Backhouse.

The early part of the shower on November 27, 1885, was well seen at Sunderland. The following table gives the number of meteors actually counted by myself at different times during the display. Column (1) contains the times at which the meteors were counted; (2), the duration in seconds of each counting; (3), the estimated proportion of clear sky in the direction of observation; (4), the number of seconds in column (2) diminished for the extent of cloud; in (5) mention is made of hindrances to visibility of meteors in the portion of sky not clouded; then (6), the number of meteors counted in each interval; (7), the number per minute corrected for the amount of cloud; lastly, in (8), the approximate average direction of the point of sight is designated.

TABLE I.

Time.			Duration of watch.	Sky.	Corrected duration of watch.	Hindrances.	Rate per minute.	Point of sight.
h	m	s						
4	25	to 35	420	1°0	420	Very bright twilight	2	0·3
5	5	to 6	60	1°0	60	Bright twilight and gaslight	5	5
5	7	50 to 9	75	1°0	75	Twilight	{ 22	17·6
5	10	50 to 11	60	1°0	60		{ 9	9
5	12	50 to 14	102	1°0	102		{ 25	14·7
5	25	50 to 27	82	1°0	82	Slight twilight	{ 26	19
5	40	40 to 41	27	0·95	44·6		{ 21	28·3
5	42	15 to 43	30	0·9	67·5		{ 63	56
6	2	0 to 2	53	1°0	53	Average altitude 40°, in south	57	64·5
6	10	40 to 11	30	1°0	50		54	64·8
6	12	15 to 14	45	1°0	150		160	64
6	41	5 to 42	5	0·6	36	Zenith, facing south α Andromedæ Polaris	33	55
7	4	12 to 5	0	0·5	24		{ 8	20
7	5	25 to 7	3	0·7	68·6		{ 30	26·1
					Thin cloud			

I also watched for four minutes—part of the time near the radiant point, and part below λ Tauri—with a $4\frac{1}{4}$ -inch Refractor (power 20) between 6^h 49^m and 56^m, when the sky was nearly clear, but saw no meteors.

Table II. compares this shower with those of 1866 and 1872.

TABLE II.

	Time of maximum observed.	Actual number seen per minute.	Amount of cloud.	No. per minute cor- rected for cloud.
	h m			
1866, Nov. 13	13 9	61	0	61
1872 „ 27	6 21 to 27 ^m	14	0.5	28
1885 „ 27	6 11	65	0	65

This probably gives a pretty fair comparison, though from other accounts of the shower of 1872 I think I did not see its maximum, as it was mostly overcast here from 6^h 40^m to 9^h 0^m; also as my eyes have been growing more sensitive, that might make a slight increase in the number of meteors seen in the late shower, compared with the previous ones.

About 6^h 17^m I recorded the magnitudes of the meteors as well as their rapid appearance would permit. The number and percentage seen of each magnitude out of a total of 35 noted is shown in

TABLE III.

	= 4	1st mag.	2nd	3rd	4th	5th	6th mag.
Number	1	4	3	7	12	8	0
Percentage	3	11	9	20	34	23	0

This was the only attempt I made to ascertain the magnitudes. I had the impression that the proportion of bright meteors was, in general, greater than at the time I observed the magnitudes. In any case it was very much greater than in 1872, certainly so previous to 7^h on that occasion. This time those as bright as *Jupiter* were very numerous, and many equalled *Venus*. Several were bright enough to cast a glow for some distance around; and one, I believe, illumined the whole sky—I did not see this one, but only its light.

All the bright meteors had bright trains, deep red in colour, but in some cases partly of other colours—chiefly whitish. The faint meteors had no perceptible trains as a rule; but those of about 3rd mag. had trains, yet too faint to show any colour. The 2nd mag. ones often showed the red. I saw but one persistent train; this was in the case of a meteor at 6^h 4^m, which equalled *Venus* at her brightest, a portion of the train being still faintly visible to the naked eye at 6^h 10^m, between γ and Π *Camelopardi*. I noted its position very exactly for comparison with any other observation of it elsewhere; but though Mr. John Stevenson reports one such seen from near Edinburgh about 6^h, this, being near β *Aquilæ*, must have been another.

Between 6^h 19^m and 28^m I took notice of the length of path and the duration of those far from the radiant point. As a rule, the brighter the meteor the longer the path and duration. The average of three 1st mag. ones gave a course of 13°, duration

1^s.9; of three 2nd mag. ones, 10° and 1^s.5. The fainter ones, say 3rd mag. and less, varied from 0^s.4 to 1^s.1 in duration; average probably 0^s.7.

I have not calculated the position of the radiant yet, but can confirm the observations of others that it was an area of several degrees in diameter. It is a striking circumstance that observers in widely distant places locate it differently, Mr. John Ballot, at Rolfontein in the Transvaal, putting it near ϵ *Trianguli* in the direction of 7. This point, as seen from the Transvaal, would be above (though not exactly above) the position of the average point of radiation derived from the observations in Europe; which fact (if the position is a correct one) suggests that the paths of the meteors may be deflected downwards by the Earth's attraction. On the other hand, Mr. H. J. Bell, observing in the Mauritius, places the radiant a few degrees north of γ *Andromedæ*. There is another reason which would partly account for the variously assigned position of the radiant point, but only partly—i.e. that a larger proportion of those meteors proceeding from the side of the radiant area nearest the zenith must be visible from any place than of those proceeding from the lower side of the area, owing to the correction required for obtaining the zenith horary number being less for the former. The motion of the radiant point observed by Denza and Schiaparelli would likewise be partly accounted for by the deflection of the paths.

I saw but two unconformable meteors, the former of them being the earliest I observed, viz. at 4^h 31^m, when *Venus* was the only star visible at the time, so far as I noticed. It was far brighter than *Venus* at her brightest. I noted its position with respect to trees, &c., and afterwards ascertained that it appeared about R.A. 29½°, D. +22°, and was directed towards about ϕ *Pegasi*. Its course was about 8° after I first saw it, and was very slow; duration probably 3^s or 4^s. It had a train of large and very bright sparks—I believe green.

The next meteor I saw occurred one or two minutes later, and was undoubtedly an *Andromede*. It was about equal to *Jupiter* in brilliancy, and appeared about R.A. 43°, D. +18°. Both this and the previous one I at first took to be fireworks, so observed them less carefully than I otherwise should have done; but the positions cannot be far wrong, especially of the first. The fact that they were meteors is proved by their having been seen from places many miles apart.

These, however, were not the earliest meteors seen here, for at 3^h 30^m, or perhaps a little earlier, one was seen in the west. It must have been exceedingly brilliant to attract attention at all, the observer being very short-sighted. The same meteor, probably, was seen at Scarborough, where it appeared in the north-west. One was also seen from near Darlington about the same time, but, as far as I can gather from the description, was in the north-east, and must therefore have been another. These seem to have been *Andromedes*.

The sky gradually clouded over here between 7^h and 7^h 15^m, and continued overcast, or nearly so, the rest of the night, so far as I observed; but the following nights were clear, affording an opportunity of observing the gradual decline of the *Andromede* shower. The next table exhibits the duration of my watch on these nights, with the number of *Andromedes* as well as of all meteors I observed:—

TABLE IV.

Day.	Time.			Duration of watch.	Corrected duration of watch.	Hindrances.	Number of <i>Andromedes</i> seen.	Number of all Meteors seen.	Hourly rate of <i>Andromedes</i> .
	h	m	h m	m	m				
1885, Nov. 28	5	55 to	6 15	11	5	Thin cloud and gaslight	1	1	12
	8	5 to	11 23	79	78		17	22	13.1
	11	25 to	12 15	33	33	Moonlight, at first very slight	4	4	7.3
Total				...	123		22	27	11.4
Nov. 29	5	41 to	11 30	52½	36	Aurora and thin cloud	5	6	8.3
	11	39 to	12 19	28½	23		3	7	7.8
	Total				...	81	8	13	8.1
Nov. 30	5	31 to	11 48	84	84		4	11	2.8
Dec. 1	5	50 to	11 43	61	61		0	3	0

After this the only decided *Andromede* I saw was a meteor on December 6; but one, which very likely belonged to the shower, appeared on the 4th.

Sunderland:
1886, February 8.

Occultations of Stars by the Moon, and Phenomena of Jupiter's Satellites, observed at Stonyhurst Observatory. By Rev. S. J. Perry, F.R.S.

1885.	Phenomena.	Limb.	G.M.T.			Remarks.
			h	m	s	
Mar. 22	Disapp. 111 <i>Tauri</i>	Dark	6	44	53.8	Sky very good.
	Reapp. „	Bright	7	50	34.4	„ „ „
22	Disapp. 117 <i>Tauri</i>	Dark	8	51	26.8	„ „ „
	Reapp. „	Bright	9	23	18.1	„ „ „
27	Disapp. B.A.C. 3529	Dark	10	17	13.3	Passing clouds.
	Reapp. „	Bright	11	17	31.9	Sky pretty good.
27	Disapp. 43 <i>Leonis</i>	Dark	11	31	55.5	Sky good.
	Reapp. „	Bright	12	21	13.8	
Sept. 25	Disapp. μ <i>Piscium</i>	Bright	8	15	47.6	Good.
	Reapp. „	Dark	9	11	46.8	
Nov. 17	Disapp. B.A.C. 8365	Dark	10	40	28.5	Very good.
	Reapp. „	Bright	11	37	56.8	Haze: observation poor.

The observations are always given in G.M.T. and not in L.M.T., the longitude, $9^{\text{m}} 52^{\text{s}}.68$ W., having been determined in 1850 by two complete trips from Liverpool to Stonyhurst and back with three excellent chronometers. The results are published in the eleventh volume of the *Monthly Notices* in a paper by the Rev. A. Weld. The above observations were all taken by the same observer, Mr. W. Carlisle, and a dark screen was always used.

Phenomena of Jupiter's Satellites.

Sat.	Phenomena.	G.M.T. h m s	Corr. of N.A. m s	Observer.	Remarks.
1885, Feb. 2					
4	Ec. Disap. Fading $\frac{1}{4}$ light	10 3 2 4 49		S. J. P.	Definition good.
	= 11th Mag. *	6 55.5		"	
	Last seen	9 7	+ 39	"	If anything, a little too early.
3	Ec. Disap. Fading $\frac{1}{2}$ light	8 59 49 9 0 54		W. C.	Passing clouds at commencement of observation.
	Last seen	2 2	+ 8	"	
19	Oc. Disap. External contact	7 14 34		"	Definition very poor. Unsteady.
	Bisection	15 28		"	
	Last seen	16 41		"	
19	Ec. Reap. First seen $\frac{1}{4}$ light	8 44 57 50 52	+ 3 3	S. J. P.	Late, from nearness to limb. Definition good, but changing.
19	Oc. Reap. First seen	9 33 5		W. C.	
	Bisection	34 44		"	Definition good.
	Last contact	36 53		"	
28	Oc. Disap. External contact	8 45 25		"	Definition good, and planet very steady.
	Bisection	47 26		"	
	Last seen	49 7		"	
March 6	Tr. Egress Internal contact	7 12 9		"	Unsteady.
	Bisection	14 33		"	
	Last contact	17 12		"	

1885, Mar. 6	Sat.	Phenomena.	G.M.T.		Corr. of N.A. m s	Observer.	Remarks.
			h	m s			
6	1	Tr. Egress External contact	7	58 50		W.C.	Definition good.
		Bisection	8	0 30		"	
		Internal contact	2	25		"	
6	3	Sh. Egress Internal contact	8	41 5		"	Definition good.
		Bisection	43	18		"	
		Last seen	45	33		"	
6	1	Tr. Egress Internal contact	10	17 5		"	Fairly good sky.
		Bisection	18	41		"	
		External contact	20	16		"	
6	1	Sh. Ingress Internal contact	10	38 59		"	Sh. exceedingly small, but dark.
		Bisection	40	0		"	
		Last seen	41	3		"	
13	1	Tr. Ingress External contact	9	45 44		"	Definition good.
		Bisection	47	32		"	
		Internal contact	49	20		"	
13	3	Tr. Egress Internal contact	10	30 48		"	Good.
		Bisection	34	5		"	
		Last contact	37	18		"	
13	1	Tr. Egress Internal contact	12	2 4		"	Definition good; limb boiling.
		Bisection	3	35		"	
		Last contact	5	2		"	

March 1886.

Satellites observed at Stonyhurst.

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	Sat.	Phenomena.	G.M.T. h m s	Corr. of N.A. m s	Observer.	Remarks.
1885, Mar. 14	1	Oc. Disap. First contact	6 51 34		W. C.	
		Bisection	53 23			Sky very hazy.
		Last seen	55 8		"	
	14	Ec. Reap. First seen	9 43 30	+ 10	"	
14		$\frac{1}{2}$ light	44 33		"	Sky very hazy.
		Full light	45 36		"	
	2	Oc. Disap. First contact	13 18 9		"	Difficult; sky bad.
		Bisection	19 58		"	
22		Last seen	21 23		"	
	1	Tr. Egress Internal contact	8 14 3		"	Tremulous. Definition fairly good.
		Bisection	15 56		"	
		Last contact	17 47		"	
April 17	2	Tr. Egress External contact	9 6 59		J. R.	Fair observation.
	18	Tr. Egress Internal contact	11 31 38		W. C.	
		Bisection	34 35		"	Sky very hazy.
		External contact	11 37 38		"	
27	4	Ec. Reap. First seen	8 36 4	+ 21	"	Good.
		$\frac{1}{2}$ light	39 58		"	
		Full light	43 41		"	
	3	Ec. Reap. First seen	17 52 19	+ 1 14	"	Very good.
Nov. 15		$\frac{1}{2}$ light	54 14		"	
		Full light	59 1		"	

Occultations observed at Beloit, Wisconsin, in 1884-85.

By J. Tatlock.

(Communicated by the Secretaries.)

From August 1884 to July 1885 I was in charge of a small Observatory at Beloit, Wisconsin, and during that time the observation of occultations of stars by the Moon was made a prominent feature of the Observatory work. Such observations of this nature as I succeeded in making are given in what follows. The list is comparatively small, but much of my time was occupied with other matters and duties, and the weather during the winter of 1884-85 and the spring of 1885 was particularly unfavourable for astronomical work in this locality.

The position of the Observatory is assumed to be—

Long. $5^{\text{h}} 56^{\text{m}} 7^{\text{s}}.30$ West of Greenwich,

Lat. $+42^{\circ} 30' 9''$.

These coordinates were determined by triangulation from points in the immediate vicinity of the Observatory which had been fixed by the State Survey of Wisconsin, whose positions depend upon the Coast Survey (telegraphic) longitude and latitude of Madison. This position is undoubtedly susceptible of correction, but I think it is abundantly accurate for the reduction of the observations contained in this paper.

The occultations were observed with an Equatorial having a Clark objective of 9.5 English inches in diameter. A power of 220 was usually employed, though some of the observations were made with a power of 100. A part of the occultations were observed by the eye-and-ear method, using a sidereal chronometer, but the majority were registered on the chronograph, with a Howard mean-time clock graduating the sheet.

I made a great effort to have the time determination as accurate as possible. The Transit was an instrument of antique construction, with an objective of 2.5 inches in diameter, and fitted with a diagonal eyepiece with a power of about 35. The instrument was rather unsteady in level and azimuth, and I consequently determined the inclination of the axis at frequent intervals, at least once for every star. The collimation was determined from the star observation, and as this demanded a reversal of the instrument, I always assumed, in the reduction, two values of the azimuth constant. The time determinations were made by the eye-and-ear method, using a sidereal chronometer, and the time was found on every night on which occulta-

tions were observed. I find that the probable error of a clock correction from a single star is $\pm 0^s.095$; and as four time stars were always observed, if possible, the probable error of an adopted clock correction is about $\pm 0^s.05$. Considering the character of the instrument, this is as good a result as could be expected. The rates of the chronometer and clock were checked by frequent comparison.

I have given in the accompanying table both the Beloit and the Greenwich time of the observations, the longitudes mentioned above having been used in the conversion. The last column of the table denotes the method according to which the observation was made, E denoting the eye-and-ear, and C the chronographic. There is a little uncertainty concerning the identity of a few of the small stars, as the facilities for identification at my disposal were extremely limited.

I have also given the places of the Moon, both geocentric and apparent, computed for the Greenwich times of the occultations. The geocentric places were taken from the *American Ephemeris and Nautical Almanac*, and the apparent places were computed by the formulæ given in Chauvenet's *Astronomy*.

I have not given the places of the stars, because I have not the necessary catalogues at hand.

No.	Date.	Star.	Phase.	Limb.	Beloit M. T.			Greenwich M. T.		
					h	m	s	h	m	s
	1884.									
1	Aug. 31	ρ' Sagittarii	Immersion	Dark	10	44	7.9	16	40	15.2 E
2	Sept. 10	D. M. + 16° 591	"	Bright	12	45	48.3	18	41	55.6 E
3	10	D. M. + 16° 602	"	"	13	45	13.0	19	41	20.3 E
4	11	115 Tauri	"	"	13	55	42.4	15	3	0.2 E
5	11	115 Tauri	Emersion	Dark	19	51	49.7	29	59	7.5 E
6	Sept. 24	χ Ophiuchi	Immersion	"	7	39	57.9	13	36	5.2 E
7	Oct. 10	λ Geminorum	"	Bright	17	14	46.0	23	10	53.3 E
8	Nov. 8	A ² Cancri	"	"	12	34	39.4	18	30	46.7 E
9	8	D. M. + 13° 1995	"	"	12	36	58.4	18	33	5.7 E
10	8	A ² Cancri	Emersion	Dark	13	40	8.2	19	36	15.5 E
11	Nov. 8	α Cancri	Immersion	Bright	18	21	38.7	24	17	46.0 E
	1885.									
12	Jan. 25	63 Tauri	"	Dark	13	14	22.2	14	4	56.5 C
13	25	63 Tauri	Emersion	Bright	19	10	29.5	20	1	3.8 C
14	Jan. 28	λ Geminorum	Immersion	Dark	6	43	6.1	12	39	13.4 C
15	Feb. 20	LL. 5725	"	"	11	15	4.4	17	11	11.7 C
16	22	B. A. C. 1526	"	"	9	2	0.2	14	58	7.5 C
17	Feb. 22	B. A. C. 1526	Emersion	Bright	9	49	32.9	15	45	40.2 C
18	Mar. 19	38 Arietis	"	"	8	21	35.4	14	17	42.7 C
19	19	D. M. + 11° 385	Immersion	Dark	8	23	33.3	14	19	40.6 C

No.	Date.	Star.	Phase.	Limb.	Beloit	Greenwich
					M. T.	M. T.
					h m s	h m s
20	^{1885.} Mar. 19	D. M. + 11° 387	Immersion	Dark	8 32 27.6	14 28 34.9 C
21	19	D. M. + 11° 386	"	"	8 33 55.5	14 30 2.8 C
22	21	D. M. + 16° 641	"	"	8 41 15.2	14 37 22.5 E
23	22	D. M. + 17° 979	"	"	8 16 14.1	14 12 21.4 C
24	22	Anon.	"	"	8 37 40.9	14 33 48.2 E
25	22	130 Tauri	"	"	10 59 29.9	16 55 37.2 C
26	22	D. M. + 17° 1006	"	"	11 5 39.2	17 1 46.5 C
27	22	D. M. + 17° 1011	"	"	11 16 39.8	17 12 47.1 C
28	22	130 Tauri	Emersion	Bright	11 48 18.5	17 44 25.8 C
29	23	D. M. + 17° 1336	Immersion	Dark	7 12 24.4	13 8 31.7 C
30	23	D. M. + 17° 1341	"	"	7 14 57.4	13 11 4.7 C
31	23	D. M. + 17° 1344	"	"	7 20 14.8	13 16 22.1 C
32	23	Anon.	"	"	7 21 56.0	13 18 3.3 C
33	Mar. 24	D. M. + 16° 1546	"	"	9 26 28.2	15 22 35.5 C
34	Apr. 20	D. M. + 16° 1493	"	"	10 1 38.4	15 57 45.7 C
35	May 21	<i>d</i> Leonis	"	"	10 57 6.7	16 53 14.0 C
36	June 16	D. M. + 9° 2338	"	"	8 50 44.2	14 46 51.5 C
37	16	D. M. + 9° 2341	"	"	9 27 6.9	15 23 14.2 C
38	16	Anon.	"	"	9 29 36.9	15 25 44.2 C
39	June 18	D. M. + 1° 2585	"	"	9 16 25.1	15 12 32.4 C

March 1886.

observed at Beloit, Wisconsin.

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No.	Date, 1884.	α	δ	π	S	$\Delta\alpha$	α'	$\Delta\delta$	δ	S
1	Aug. 31	289 0 22.22	-17 4 48.79	55 6.40	900.20	-23 17.21	288 37 5.01	-45 42.97	-17 50 31.76	905.85
2	Sept. 10	63 36 32.44	+17 7 5.10	59 21.13	969.62	+40 32.44	64 17 4.88	-32 19.43	+16 34 45.67	978.55
3	10	64 13 5.84	+17 11 14.84	59 21.03	969.59	+33 56.33	64 47 2.17	-29 41.98	+16 41 32.86	980.99
4	11	79 10 47.49	+18 17 37.19	59 15.08	968.02	+39 34.42	79 50 21.91	-31 0.83	+17 46 36.36	977.65
5	11	79 52 34.07	+18 19 0.76	59 14.72	967.92	+31 21.16	80 23 55.23	-28 2.12	+17 50 58.64	980.17
6	Sept. 24	245 30 28.53	-17 17 13.51	54 13.55	885.88	-34 2.09	244 56 26.44	-41 55.38	-17 59 8.89	888.82
7	Oct. 10	107 28 24.94	+17 9 28.31	58 56.56	962.99	+6 41.52	107 35 6.46	-25 32.65	+16 43 55.66	977.99
8	Nov. 8	129 35 58.19	+13 35 38.38	58 38.22	958.00	+42 33.18	130 18 31.37	-35 27.80	+13 0 10.58	964.11
9	8	129 37 18.70	+13 35 20.92	58 38.12	957.97	+42 25.21	130 19 43.91	-35 22.39	+12 59 58.53	964.21
10	8	130 13 51.48	+13 27 23.00	58 36.07	957.42	+37 17.23	130 51 8.71	-33 4.56	+12 54 18.44	966.46
11	Nov. 8	132 55 43.54	+12 50 57.11	58 26.92	954.94	-8 58.85	132 46 44.69	-29 19.54	+12 21 37.57	968.48
12	1885. Jan. 25	64 42 53.46	+16 59 12.28	59 51.14	977.78	-45 33.57	63 57 19.89	-36 25.85	+16 22 46.43	983.20
13	25	65 14 30.44	+17 2 59.22	59 52.30	978.09	-46 11.95	64 28 18.49	-39 4.42	+16 23 54.80	980.05
14	Jan. 28	107 1 11.50	+17 29 33.45	60 46.78	993.00	+40 6.65	107 41 18.15	-32 10.06	+16 57 23.39	1003.13
15	Feb. 20	45 33 14.64	+13 34 11.14	58 28.58	955.30	-44 13.87	44 49 0.77	-39 7.36	+12 55 3.78	956.82
16	22	72 56 36.98	+17 37 48.51	59 16.10	968.23	-27 6.29	72 29 30.69	-27 36.06	+17 10 12.45	981.30
17	Feb. 22	73 25 57.60	+17 40 8.29	59 16.78	968.42	-33 59.32	72 51 58.28	-29 19.21	+17 10 49.08	979.87
18	Mar. 19	40 36 0.09	+12 23 35.67	58 40.64	958.60	-44 3.42	39 51 56.67	-37 31.45	+11 46 4.22	962.37
19	19	40 37 8.28	+12 23 51.56	58 40.68	958.61	-44 5.98	39 53 2.30	-37 35.79	+11 46 15.77	962.28
20	19	40 42 17.46	+12 25 3.55	58 40.81	958.65	-44 21.35	39 57 56.11	-37 55.60	+11 47 7.95	961.88
21	19	40 43 8.37	+12 25 15.34	58 40.83	958.65	-44 16.38	39 58 51.99	-37 58.74	+11 47 17.60	961.81

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A

No.	Date, 1884.	α	δ	π	S	$\Delta\alpha$	α'	$\Delta\delta$	δ'	S
22	Mar. 21	$69^{\circ} 26' 43'' 14$	$+17^{\circ} 14' 24'' 53$	59 $8^{\circ} 04$	966 ⁰⁰ 5	$-50^{\circ} 28' 98$	$68^{\circ} 36' 14'' 16$	$-31^{\circ} 59' 51$	$+16^{\circ} 42' 25'' 02$	975 ⁰⁷
23	22	$83^{\circ} 59' 43'' 8$	$+18^{\circ} 7' 57'' 56$	59 $13^{\circ} 83$	967 ⁷⁰	$-30^{\circ} 22' 53$	$83^{\circ} 29' 21'' 25$	$-27^{\circ} 55' 39$	$+17^{\circ} 40' 2'' 17$	980 ¹⁴
24	22	$84^{\circ} 13' 17'' 2$	$+18^{\circ} 8' 16'' 21$	59 $13^{\circ} 89$	967 ⁷²	$-33^{\circ} 23' 29$	$83^{\circ} 39' 38'' 43$	$-28^{\circ} 45' 45$	$+17^{\circ} 39' 30'' 76$	979 ⁴¹
25	22	$85^{\circ} 40' 59'' 92$	$+18^{\circ} 9' 56'' 55$	59 $14^{\circ} 24$	967 ⁸²	$-45^{\circ} 26' 26$	$84^{\circ} 55' 33'' 66$	$-35^{\circ} 45' 56$	$+17^{\circ} 34' 10'' 99$	973 ²⁴
26	22	$85^{\circ} 44' 48'' 98$	$+18^{\circ} 9' 59'' 89$	59 $14^{\circ} 25$	967 ⁸²	$-45^{\circ} 36' 96$	$84^{\circ} 59' 12'' 02$	$-36^{\circ} 5' 88$	$+17^{\circ} 33' 54'' 01$	972 ⁰⁶
27	22	$85^{\circ} 51' 38'' 85$	$+18^{\circ} 10' 5' 87$	59 $14^{\circ} 26$	967 ⁸¹	$-45^{\circ} 51' 23$	$85^{\circ} 5' 47'' 62$	$-36^{\circ} 42' 37$	$+17^{\circ} 33' 23'' 50$	972 ³⁸
28	22	$86^{\circ} 11' 17'' 02$	$+18^{\circ} 10' 21'' 65$	59 $14^{\circ} 36$	967 ⁸³	$-45^{\circ} 59' 30$	$85^{\circ} 25' 17'' 72$	$-38^{\circ} 27' 73$	$+17^{\circ} 31' 53'' 92$	970 ¹⁷
29	23	$98^{\circ} 13' 26'' 60$	$+17^{\circ} 56' 58'' 66$	59 $15^{\circ} 18$	968 ⁰⁰	$-9^{\circ} 20' 07$	$98^{\circ} 4' 6'' 53$	$-25^{\circ} 3' 67$	$+17^{\circ} 31' 54'' 99$	983 ¹⁶
30	23	$98^{\circ} 15' 1' 32$	$+17^{\circ} 56' 53'' 96$	59 $15^{\circ} 17$	968 ⁰⁰	$-9^{\circ} 49' 32$	$98^{\circ} 5' 12'' 00$	$-25^{\circ} 5' 05$	$+17^{\circ} 31' 48'' 91$	982 ¹³
31	23	$98^{\circ} 18' 17'' 85$	$+17^{\circ} 56' 44'' 15$	59 $15^{\circ} 17$	968 ⁰⁰	$-10^{\circ} 49' 76$	$98^{\circ} 7' 28'' 09$	$-25^{\circ} 10' 07$	$+17^{\circ} 31' 34'' 08$	983 ⁰⁶
32	23	$98^{\circ} 19' 20'' 54$	$+17^{\circ} 56' 41'' 02$	59 $15^{\circ} 17$	968 ⁰⁰	$-11^{\circ} 8' 97$	$98^{\circ} 8' 11'' 57$	$-25^{\circ} 11' 50$	$+17^{\circ} 31' 29'' 52$	983 ⁰⁴
33	Mar. 24	$114^{\circ} 20' 41'' 54$	$+16^{\circ} 29' 15'' 46$	59 $11^{\circ} 32$	966 ⁹⁹	$-23^{\circ} 4' 37$	$113^{\circ} 57' 37'' 17$	$-27^{\circ} 48' 20$	$+16^{\circ} 1' 29'' 26$	980 ⁴⁹
34	Apr. 20	$111^{\circ} 25' 43'' 80$	$+16^{\circ} 54' 38'' 60$	59 $20^{\circ} 97$	969 ⁶⁵	$-42^{\circ} 47' 06$	$110^{\circ} 42' 56'' 74$	$-33^{\circ} 48' 16$	$+16^{\circ} 20' 50'' 44$	976 ⁶⁵
35	May 21	$164^{\circ} 2' 9'' 32$	$+4^{\circ} 56' 34'' 62$	59 $49^{\circ} 07$	944 ⁵⁹	$-37^{\circ} 25' 37$	$163^{\circ} 24' 43'' 95$	$-37^{\circ} 10' 02$	$+4^{\circ} 19' 24'' 60$	951 ²³
36	June 16	$145^{\circ} 45' 17'' 32$	$+10^{\circ} 34' 58'' 70$	59 $37^{\circ} 18$	974 ⁰⁰	$-42^{\circ} 52' 45$	$145^{\circ} 2' 24'' 87$	$-37^{\circ} 12' 99$	$+9^{\circ} 57' 45'' 71$	979 ⁶⁸
37	16	$146^{\circ} 6' 36'' 86$	$+10^{\circ} 29' 16'' 87$	59 $35^{\circ} 99$	973 ⁶⁸	$-44^{\circ} 18' 83$	$145^{\circ} 22' 18'' 03$	$-38^{\circ} 22' 01$	$+9^{\circ} 50' 54'' 86$	977 ⁴⁹
38	16	$146^{\circ} 8' 4' 72$	$+10^{\circ} 28' 53'' 33$	59 $35^{\circ} 91$	973 ⁶⁶	$-44^{\circ} 22' 51$	$145^{\circ} 23' 42'' 21$	$-38^{\circ} 26' 20$	$+9^{\circ} 50' 27'' 13$	977 ³⁴
39	18	$172^{\circ} 48' 35'' 31$	$+2^{\circ} 21' 1' 63$	57 $54^{\circ} 65$	946 ⁰⁶	$-34^{\circ} 47' 45$	$172^{\circ} 13' 47'' 86$	$-38^{\circ} 9' 29$	$+1^{\circ} 42' 52'' 34$	953 ³⁹

Hoosac Falls, N.Y., U.S.A.: 1885, January 14.

Erratum in Annual Report, 1886.

Page 207, line 19 from bottom, *for deviation read direction.*

* * The Council are indebted to the Editor of *Nature* for permission to insert the obituary notice of Sir F. J. O. Evans, published in the Annual Report.

